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NOTES ON THE TAXONOMY OF SOME GLASSFROGS FROM THE ANDES OF PERU AND ECUADOR (AMPHIBIA: CENTROLLENIDAE)

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ABSTRACT

We present new information on several species of centrolenid frogs from Ecuador and Peru that justify the placement of Centrolene fernandoi Duellman and Schulte as a junior synonym of Centrolenella audax Lynch and Duellman; Centrolenella puyoensis Flores & McDiarmid as a synonym of Centrolenella mariae Duellman & Toft; and Cochranella tangarana Duellman & Schulte as a synonym of Cochranella saxiscandens Duellman & Schulte.

KEY-WORDS: *Centrolene fernandoi*; *Centrolene audax*; *Nymphargus puyoensis*; *Nymphargus mariae*; *Rulyrana saxiscandens*; *Rulyrana tangarana*; *Rulyrana spiculata*; Synonymy.

INTRODUCTION

Glassfrogs are conspicuous members of riverine communities across Neotropical America and have more than 140 described species (Frost, 2013). Twenty-nine species of glassfrogs have been reported from Peru (see below). *Nymphargus ocellatus* Boulenger was the first centrolenid species to be described from Peru (Boulenger, 1918), and no further glassfrogs were reported from the country until Duellman's (1976) description of *Nymphargus truebae* Duellman and *Rulyrana spiculata* Duellman, who also reported *Nymphargus siren* (Lynch & Duellman) and *Hyalinobatrachium munozorum* Lynch & Duellman. In 1979, *Nymphargus mariae* Duellman & Toft was described from the Serranía del Sira. Cannatella & Duellman (1982) re-evaluated the Peruvian specimens assigned

to *N. siren* and regarded them as a different species: *Nymphargus phenax* (Cannatella & Duellman). They also described *Nymphargus pluvialis* (Cannatella & Duellman), and provided the first Peruvian records for *Teratohyla midas* (Lynch & Duellman) and *Hyalinobatrachium bergeri* (Cannatella). *Centrolene azulae* (Flores & McDiarmid) was described in subsequent years from an isolated mountain range on the eastern Andes of Peru, while *Centrolene hesperium* (Cadle & McDiarmid) and *Cochranella euhystrix* (Cadle & McDiarmid) were described from the Pacific slopes of northwestern Andean Peru (Flores & McDiarmid, 1989; Cadle & McDiarmid, 1990). Duellman & Wild (1993) provided the first country record of *Centrolene buckleyi* Boulenger. Duellman & Schulte (1993) almost doubled the number of Peruvian centrolenids with the description of eight species from

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the eastern slopes of Cordillera Central and adjacent ridges in the department of San Martín: *Centrolene fernandoi* Duellman & Schulte, *Centrolene lemniscatum* Duellman & Schulte, *Centrolene muelleri* Duellman & Schulte, *Nymphargus chancas* (Duellman & Schulte), *Cochranella croceopodes* Duellman & Schulte, *Rulyrana saxiscandens* (Duellman & Schulte), *R. tangarana* (Duellman & Schulte), and *Hyalinobatrachium lemur* Duellman & Schulte. *Nymphargus mixomaculatus* (Guayasamin, Lehr, Rodríguez & Aguilar) was described from central Andean Peru (Guayasamin *et al.*, 2006). Torres-Gastello *et al.* (2007) described *Rulyrana erminea* Torres-Gastello, Suárez-Segovia & Cisneros-Heredia, and reported the first records of *Cochranella resplendens* (Lynch & Duellman) and *Vitreorana oyampiensis* Lescure from Amazonian Peru. Cisneros-Heredia *et al.* (2008) described *Rulyrana mdiarmidi* from Ecuador and Peru, and presented the first record of *Nymphargus posadae* from Peru. Yáñez-Muñoz *et al.* (2009) reported the first Peruvian record of *Hyalinobatrachium iaspidiense* Ayarzagüena from Amazonian Peru. Castroviejo-Fisher *et al.* (2009) described *Hyalinobatrachium carlesvilai* Castroviejo-Fisher, Padial, Chaparro, Aguayo & de la Riva from the Amazonian slopes of central Andean Peru, assigned all previous records of *H. munozorum* from Peru either to *H. carlesvilai* or to *H. bergeri*, synonymized *H. lemur* with *H. pellucidum* Lynch & Duellman, and extended the distribution of the latter south to the department of Cusco, southern Peru. Catenazzi *et al.* (2012) described *Centrolene sabini* Catenazzi, von May, Lehr, Gagliardi-Urrutia & Guayasamin from the Amazonian slopes of southeastern Andean Peru. Catenazzi & Venegas (2012) presented photographs of *Chimerella mariaelenae* (Cisneros-Heredia & McDiarmid) from Kampankis, in the Amazonian slopes of northeastern Peru.

While developing our extensive reviews of Centrolenidae (Cisneros-Heredia & McDiarmid, 2007; Guayasamin *et al.*, 2009), we cooperatively found that there is no evidence to support specific recognition of several populations of Peruvian and Ecuadorian centrolenids currently hypothesised as different species. Herein, we present our findings in an effort to enhance the understanding on the diversity and conservation of Neotropical amphibians.

MATERIALS AND METHODS

Characters and terminology are standardized following the definitions provided by Cisneros-Heredia & McDiarmid (2007). Taxonomy and systemat-

ics follow Guayasamin *et al.* (2009). The following measurements (in millimetres) were taken with electronic digital callipers (0.05 mm accuracy, rounded to the nearest 0.1 mm): snout-vent length, SVL; head width, HW; head length, HL; horizontal eye diameter, ED; inter-orbital distance, IOD; eye-nostril distance, EN; inter-narial distance, IN; width of disc on the third finger, 3DW; tibia length, TL; foot length, FL. Upper eyelid width was not measured because of its limited utility due to preservation bias. We use the notational device for webbing formulae of Savage & Heyer (1967), as modified by Savage & Heyer (1997). Sex and sexual maturity was determined by direct examination of the condition of gonads and development of secondary sexual characters (vocal slits and nuptial pads). We examined specimens (Appendix I) deposited in the following collections: DHMECN – División de Herpetología, Museo Ecuatoriano de Ciencias Naturales, Quito; DFCH-USFQ – Universidad San Francisco de Quito, Quito; QCAZ – Museo de Zoología, Pontificia Universidad Católica del Ecuador, Quito; BMNH – Natural History Museum, London; KU – The University of Kansas, Natural History Museum, Lawrence; USNM – National Museum of Natural History, Washington, D.C.; MCZ – Museum of Comparative Zoology, Harvard University.

RESULTS AND CONCLUSIONS

Centrolene audax Lynch & Duellman, 1973 (Fig. 1)

Centrolenella audax Lynch & Duellman, 1973.

Centrolene audax – Ruiz-Carranza & Lynch, 1991.

“*Centrolene*” *audax* – Guayasamin *et al.*, 2009.

Centrolene fernandoi – Duellman & Schulte, 1993.

Holotype: KU 211770. *Type locality*: west slope of Abra Tangarana, 7 km (by road) northeast of San Juan de Pacaysapa (06°12'S, 76°44'W, 1080 m), Provincia Lamas, Departamento San Martín, Perú. New synonymy.

Lynch & Duellman (1973) described *Centrolenella audax* for glassfrog populations diagnosed as having small yellow spots on the dorsum, short and distally-curved humeral spines in males, and extensive webbing between outer fingers from the Amazonian versant of the northern Andes. *Centrolene audax* is currently known in Colombia and Ecuador from few localities in Low Montane Evergreen Forest on the Amazonian versant of the Andes, between 1350 and

1800 m (Mueses-Cisneros, 2005; Cisneros-Heredia & McDiarmid, 2007; Yáñez-Muñoz *et al.*, 2010).

Centrolene fernandoi Duellman & Schulte (1993) was described based on nine specimens collected on the western slope of Abra Tangarana, Amazonian versant of the Andes of Peru. Duellman & Schulte (1993) compared *C. fernandoi* with *Centrolene audax* and reported its high similarity, but differentiated them by its snout form (bluntly rounded in *C. fernandoi*, truncate in *C. audax*), dorsal skin texture (with scattered small spicules in *C. fernandoi*, without spicules in *C. audax*), dorsal fleck colouration (bluish-white in *C. fernandoi*, golden in *C. audax*), finger colouration (pale green in *C. fernandoi*, pale yellow in *C. audax*), and iris background colouration (silvery green in *C. fernandoi*, pale bronze in *C. audax*). *Centrolene fernandoi* remains known only from its type locality (Frost, 2011).

We examined six specimens of *Centrolene fernandoi* (type-series) and 42 specimens of *Centrolene audax* (including the type-series). We found that all

differences used to separate them are intraspecifically variable within *C. audax*. Snout form of *C. audax* varies between rounded to truncate in profile, presence of spicules shows sexual and ontogenic variation (visible in reproductive males, and absent in non-reproductive males and females), dorsal flecks vary from pale yellow to golden yellow (furthermore, the photograph of *C. fernandoi* in the original description shows pale yellow spots), finger colouration varies from pale green to bright yellow, and iris colouration varies from pale bronze to silvery green or mustard with thin black reticulation. Since no discrete differences are evident and their populations have no obvious biogeographic barriers, we place *Centrolene fernandoi* Duellman & Schulte, 1993 as a junior synonym of *Centrolenella audax* Lynch & Duellman, 1973. Therefore, *Centrolene audax* inhabits Low Montane Evergreen Forest on the Amazonian versant of the Andes of southern Colombia, Ecuador, and northern Peru, between 1080 and 1800 m (Duellman & Schulte, 1993; Mueses-Cisneros, 2005; Cisneros-Heredia & McDiarmid, 2007; Yáñez-Muñoz *et al.*, 2010).



FIGURE 1: Photographs of *Centrolene audax*: (A) KU 164500 from 2 km SSW of Río Reventador, Napo, Ecuador; (B) KU 211770, holotype of *Centrolene fernandoi*, from W slope of Abra Tangarana, San Martín, Peru. Photos by W.E. Duellman.

Nymphargus mariae (Duellman & Toft, 1979) (Fig. 2)

Centrolenella mariae Duellman & Toft, 1979.

Centrolenella puyoensis – Flores & McDiarmid, 1989.

Holotype: MCZ 91187, by original designation.

Type locality: “1.0 km W Puyo, Provincia de Pastaza, Ecuador, between 1000-1050 m elevation”. New synonymy.

Cochranella mariae – Ruiz-Carranza & Lynch, 1991.

Cisneros-Heredia & McDiarmid, 2007.

Cochranella puyoensis – Ruiz-Carranza & Lynch,

1991. Cisneros-Heredia & McDiarmid, 2006.

Centrolene mariae – Duellman & Schulte, 1993.

Centrolene puyoensis – Duellman & Schulte, 1993.

Centrolene puyoense – Stuart *et al.*, 2008.

Nymphargus mariae – Guayasamin *et al.*, 2009.

Nymphargus puyoensis – Guayasamin *et al.*, 2009.

Centrolenella mariae Duellman & Toft was described based on one female specimen collected at Serranía de Sira, department of Huánuco, Peru (Duellman & Toft, 1979). Flores & McDiarmid (1989) described *Centrolenella puyoensis* and *Centrolenella azulae*, hypothesising that, together with *C. mariae*, they formed a monophyletic group (the *C. mariae* species-group). Subsequent authors (Ruiz-Carranza & Lynch, 1991, 1995; Duellman & Schulte, 1993) followed this hypothesis, but Cisneros-Heredia &

McDiarmid (2006, 2007) questioned the validity of the *C. mariae* species-group, further pointing out that although *C. azulae* is diagnosable, *C. mariae* and *C. puyoensis* are very similar and probably conspecific (Cisneros-Heredia & McDiarmid, 2007). *Centrolenella mariae* and *C. puyoensis* were placed in the genus *Nymphargus* by Guayasamin *et al.* (2009) based on

morphological and molecular data, respectively. Flores & McDiarmid (1989) separated *N. puyoensis* from *N. mariae* by tympanum exposure (three-quarters in *N. puyoensis*, one-half in *N. mariae*), hand and foot webbing (slightly more extensive in *N. mariae*), ulnar fold (present in *N. puyoensis*, absent in *N. mariae*), intricate cloacal ornamentation (present in *N. puyoensis*,

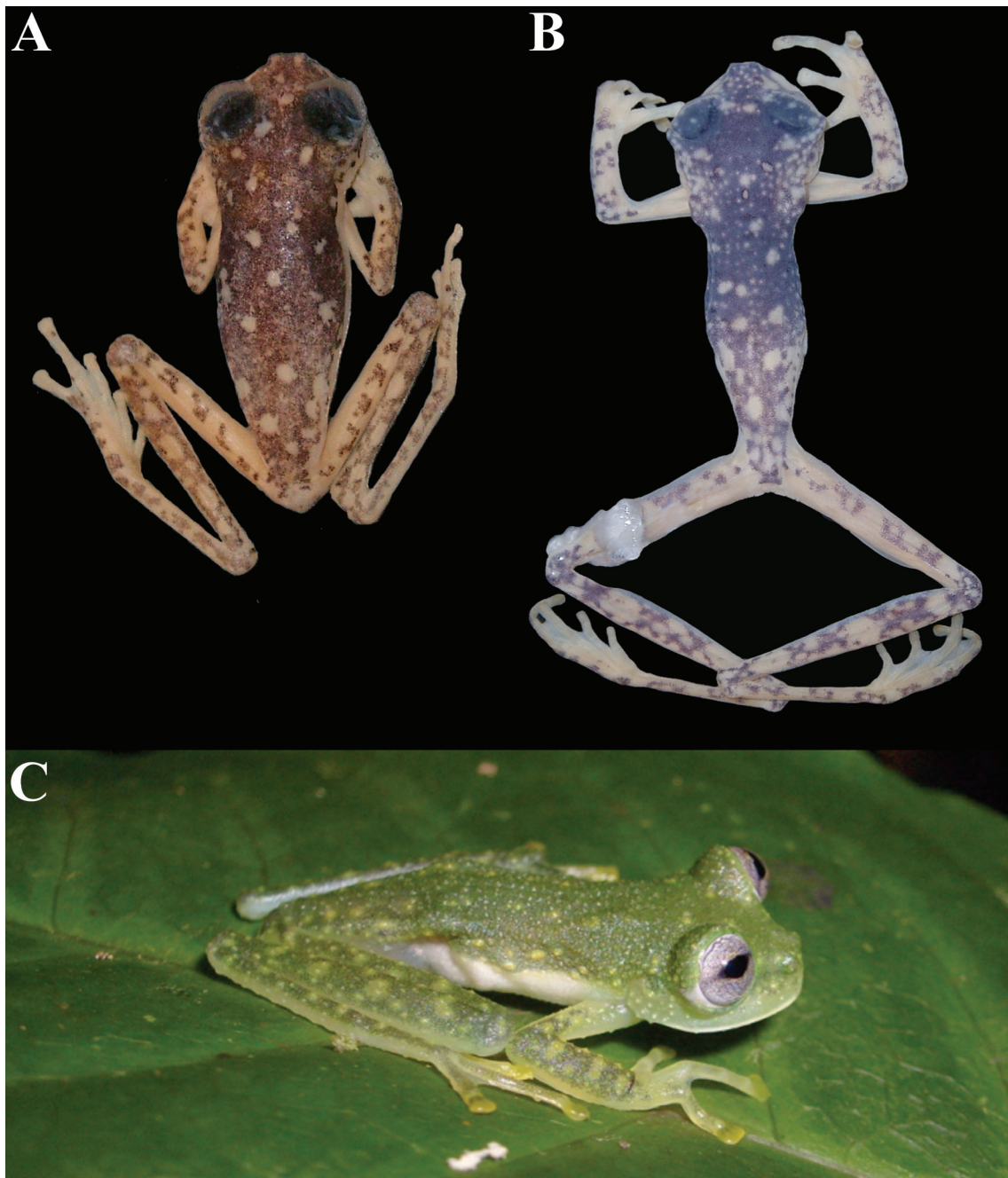


FIGURE 2: Photographs of *Nymphargus mariae*: (A) KU 174713, holotype of *Centrolenella mariae*, from Serranía de Sira, Huanuco, Peru; (B) MCZ 91187, holotype of *Centrolenella puyoensis*, from 1 km W of Puyo, Pastaza, Ecuador. (C) DHMECN 4752, from Conambo, Pastaza, Ecuador. Photo A by M. Bustamante; B by JMG; C by H.M. Ortega-Andrade.

absent in *N. mariae*) and differences in proportions (greater eye-nostril/eye diameter and shank length/snout-vent length in *N. puyoensis*).

We examined 16 specimens assignable to *Nymphargus puyoensis* from Ecuador and the holotype of *Nymphargus mariae* and found no evidence to support their differentiation. All characters used to diagnose these two species can be attributed to subtle differences that fall inside the intraspecific variation of a single species. Flores & McDiarmid (1989) proposed a polarization of characters that is rather subjective and biased due to their small sample size (one specimen for each of their “species”). Variation of tympanum exposure, webbing, and body proportions observed among *N. puyoensis* and *N. mariae* is continuous and similar, or even lower than the natural differences observed within populations of other species of centrolenids. The absence of ulnar folds and cloacal ornamentations in the type specimen of *N. mariae* could be attributed to natural variation, but also due to preservation artifacts (see Cisneros-Heredia & McDiarmid, 2006 for information on the variation of specimens of *N. puyoensis*). Either way it has also been observed in specimens of *N. puyoensis*.

In the absence of valid discriminating evidence to support the hypothesis that *Nymphargus puyoensis* and *Nymphargus mariae* are different lineages, we place *Centrolenella puyoensis* Flores & McDiarmid, 1989 as a synonym of *Centrolenella mariae* Duellman & Toft, 1979. Thus, *Nymphargus mariae*, as herein redefined, inhabits Foothill Evergreen Forest and Lowland Evergreen Forest flooded by White-water Rivers on the Amazonian versant of the Andes of Ecuador and Peru (Cordillera del Sira), between 300 and 1550 m (Flores & McDiarmid, 1989; Cisneros-Heredia & McDiarmid, 2006, 2007; Yáñez-Muñoz *et al.*, 2010).

This synonym reflects the absence of evidence to support the hypothesis that the population from the Serranía del Sira in eastern Amazonian Peru (type-locality of *Nymphargus mariae*) is different from those of eastern Amazonian Ecuador. Although it might be argued that the Serranía del Sira is a rather isolated mountain range that likely contains several amphibian endemics, our decision to place *Nymphargus puyoensis* in the synonymy of *N. mariae* is based on the fact that there are no morphological traits that support the existence of two putative species, and that potential biogeographic barriers cannot justify specific status without the corroboration of traits intrinsic to the organisms. We encourage future researchers to analyse other lines of evidence to evaluate the status of these populations.

***Rulyrana saxiscandens* (Duellman & Schulte, 1993)
(Fig. 3)**

Cochranella saxiscandens Duellman & Schulte, 1993.

Cochranella tangarana Duellman & Schulte, 1993.

Type locality: “west slope of Abra Tangarana, 7 km (by road) northeast of San Juan de Pacay-sapa (06°12’S, 76°44’W), 1080 m), Provincia Lamas, Departamento San Martín, Perú”. New synonymy.

Rulyrana saxiscandens – Guayasamin *et al.*, 2009.

Rulyrana tangarana – Guayasamin *et al.*, 2009.

Duellman & Schulte (1993) described *Cochranella saxiscandens* and *Cochranella tangarana* based on specimens collected at two nearby localities of the Mayo River, Tarapoto region, department of San Martín, Peru. Duellman & Schulte (1993) dif-

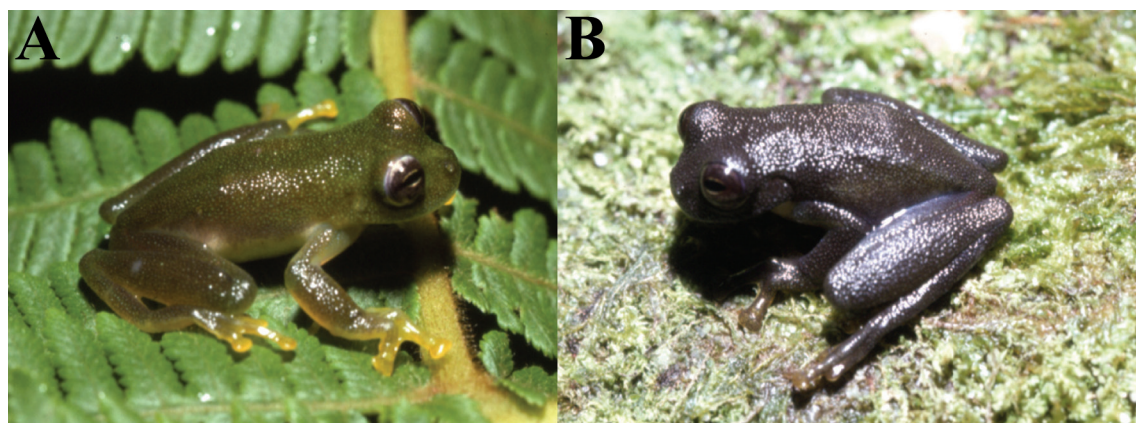


FIGURE 3: Photographs of *Rulyrana saxiscandens*: (A) KU 211776, holotype of *Cochranella tangarana*, and (B) KU 211779, holotype of *Cochranella saxiscandens*, both from Abra Tangarana, San Martín, Peru. Photos by W.E. Duellman.

ferentiated these two species (now placed in the genus *Rulyrana*) by their snout form (bluntly round in *Rulyrana saxiscandens*, truncate in *Rulyrana tangarana*), dorsal colouration in preservative (dark-grey to black in *R. saxiscandens*, lavender in *R. tangarana*), melanophores on the ventral surfaces of shanks and tarsi (present in *R. saxiscandens*, absent in *R. tangarana*); presence of spicules on dorsal surfaces (absent in *R. saxiscandens*, present in *R. tangarana*); and inner tarsal fold (absent in *R. saxiscandens*, present in *R. tangarana*).

We examined 22 specimens of *Rulyrana saxiscandens* and two of *Rulyrana tangarana* (including all type-specimens) and found that all stated differences between them actually correspond to intraspecific variation. Snout shape varies continuously from round to truncate; tympanic annulus is conspicuous at different degrees due to the supratympanic fold; dorsal colouration in preservative varies continuously from dark-purple, purplish-grey, dark-lavender, to light-lavender (similar colour variation has been observed in *Rulyrana flavopunctata*); melanophores are always present on ventral surfaces although sometimes scarce; spicule presence and appearance varies ontogenically and sexually (see Cisneros-Heredia & McDiarmid, 2007); and inner tarsal fold is always present but sometimes poorly noticeable.

In the absence of evidence to support the hypothesis that two species are involved in the populations of the Mayo River, we place *Cochranella tangarana* Duellman & Schulte, 1993 as synonym of *Cochranella saxiscandens* Duellman & Schulte, 1993.

Rulyrana saxiscandens remains very similar to *Rulyrana spiculata* (Duellman, 1976), which is known from forests on the Amazonian versant of the Andes of central and southern Peru and eastern Bolivia, between 1200 and 1700 m (Frost, 2011; Rodríguez *et al.*, 2004). Duellman & Schulte (1993) reported that *Centronella saxiscandens* (and *Centrolenella tangarana*) were similar to *Centrolenella spiculata*, but differed due to snout form, tympanum and inner tarsal fold appearance, coloration, and presence of spicules on dorsal surfaces in *Rulyrana tangarana*. Evan Twomey and associates are studying these species, and we refer to them for a definitive conclusion.

With the present changes, the diversity of glassfrogs of Peru currently includes 29 species: *Centrolene audax*, *C. azulae*, *C. buckleyi*, *C. hesperium*, *C. lemniscatum*, *C. muelleri*, *C. sabini*, *Chimerella mariaelenae*, *Cochranella croceopodes*, *C. euhystrix*, *C. resplendens*, *Hyalinobatrachium bergeri*, *H. carlesvilai*, *H. iaspidiense*, *H. pellucidum*, *Rulyrana erminea*, *R. mcdiarmidi*, *R. saxiscandens*, *R. spiculata*, *Vitreorana oyampiensis*,

Nymphargus chancas, *N. mariae*, *N. mixomaculatus*, *N. ocellatus*, *N. phenax*, *N. pluvialis*, *N. posadae*, *Terratohyla ameliae*, *T. midas*.

Hyalinobatrachium munozorum and *Centrolene condor* are expected to occur in Peru. *Hyalinobatrachium munozorum* occurs in Ecuador and Bolivia (Cisneros-Heredia & McDiarmid 2007, Castroviejo-Fisher *et al.*, 2011), and *C. condor* is known from several localities in the Cordillera del Condor, just a few kilometres from Peruvian territory (Cisneros-Heredia & Morales-Mite, 2008; Almendáriz & Batallas, 2012).

RESUMEN

Presentamos nueva información sobre algunas especies de ranas centrolénidas de Ecuador y Perú que justifica colocar a *Centrolene fernandoi* Duellman and Schulte como sinónimo junior de *Centrolenella audax* Lynch and Duellman, *Centrolenella puyoensis* Flores & McDiarmid como sinónimo de *Centrolenella mariae* Duellman & Tóft, y *Cochranella tangarana* Duellman & Schulte como sinónimo de *Cochranella saxiscandens* Duellman & Schulte.

PALABRAS-CLAVE: *Centrolene fernandoi*; *Centrolene audax*; *Nymphargus puyoensis*; *Nymphargus mariae*; *Rulyrana saxiscandens*; *Rulyrana tangarana*; *Rulyrana spiculata*; Sinonimia.

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APPENDIX I

Examined specimens

Centrolene audax: ECUADOR: Napo: KU 146624 (holotype of *Centrolenella audax*): Salto de Agua; KU 155502-03: 7 km SW of Río Azuela; KU 164496: Azuela; KU 164497-504: 2 km SSW of Río Reventador; USNM 286620-22: Cascada de San Rafael; KU 178018-27: Río Salado; USNM 286623-25, MCZ A97807-8: 14.6 km (by road) NE of Río Salado; KU 190015: 43 km NE of Santa Rosa; KU 190016: 8.9 km NE Santa Rosa; KU 143290, 143292: 16,5 km NNE Santa Rosa; DHMECN 06788-89: Reserva Biológica Narupa. PERU: San Martín: KU 211770 (holotype of *Centrolene fernandoi*), 211771-5: W slope Abra Tangarana.

Nymphargus mariae: ECUADOR: Napo: DFCH-USFQ D285: ca. 45 km E of Narupa. PASTAZA: MCZ 91187 (holotype of *Centrolenella puyoensis*): 1.0 km W Puyo; USNM 291298: Río Pucayacu. QCAZ 37932: stream tributary of Río Lliquino; QCAZ 39293: near Villano; DHMECN 04752-53, 04756: Conambo; Orellana: QCAZ 7104, 7499: Río Huataracu; Sucumbíos: DHMECN 06190: Río Verde. PERU: Huanuco: KU 174713 (holotype of *Centrolenella mariae*): Serranía de Sira.

Rulyrana saxiscandens: PERU: KU 211776 (holotype of *Cochranella tangarana*), 211777, 217299: W slope of Abra Tangarana; KU 211779 (holotype of *Cochranella saxiscandens*), 211780-88, 211789-98, 211800-01: Cataratas Ahaushiyacu; KU 211802-03: 15 km NE of Tarapoto.